Document Number: AFT05MS004N
Rev. 0, 7/2014

RoHS

RF Power LDMOS Transistor

High Ruggedness N–Channel Enhancement–Mode Lateral MOSFET

Designed for handheld two–way radio applications with frequencies from 136 to 941 MHz. The high gain, ruggedness and wideband performance of this device make it ideal for large–signal, common–source amplifier applications in handheld radio equipment.

Narrowband Performance (7.5 Vdc, T_A = 25°C, CW)

Frequency (MHz)	G_{ps} (dB)	η_D (%)	P_{out} (W)
520 (1)	20.9	74.9	4.9

Wideband Performance (7.5 Vdc, T_A = 25°C, CW)

Frequency (MHz)	P_{in} (W)	G_{ps} (dB)	η_D (%)	P_{out} (W)
136–174 (2)	0.10	17.8	61.8	6.1
350–520 (3)	0.12	15.4	49.4	4.2

Load Mismatch/Ruggedness

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage	Result
435(3)	CW	> 65:1 at all Phase Angles	0.24 (3 dB Overdrive)	9.0	No Device Degradation

1. Measured in 520 MHz narrowband test circuit.
2. Measured in 136–174 MHz VHF broadband reference circuit.
3. Measured in 350–520 MHz UHF broadband reference circuit.

Features

- Characterized for Operation from 136 to 941 MHz
- Unmatched Input and Output Allowing Wide Frequency Range Utilization
- Integrated ESD Protection
- Integrated Stability Enhancements
- Wideband — Full Power Across the Band
- Exceptional Thermal Performance
- Extreme Ruggedness
- In Tape and Reel. T1 Suffix = 1,000 Units, 12 mm Tape Width, 7–inch Reel.

Typical Applications

- Output Stage VHF Band Handheld Radio
- Output Stage UHF Band Handheld Radio
- Output Stage for 700–800 MHz Handheld Radio
- Driver for 10–1000 MHz Applications

AFT05MS004NT1

136–941 MHz, 4 W, 7.5 V
WIDEBAND
RF POWER LDMOS TRANSISTOR



SOT–89

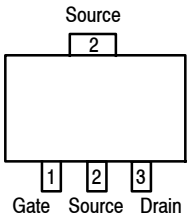


Figure 1. Pin Connections

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freescale Airfast

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	–0.5, +30	Vdc
Gate-Source Voltage	V_{GS}	–6.0, +12	Vdc
Operating Voltage	V_{DD}	12.5, +0	Vdc
Storage Temperature Range	T_{stg}	–65 to +150	°C
Case Operating Temperature Range	T_C	–40 to +150	°C
Operating Junction Temperature Range (1,2)	T_J	–40 to +150	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	28 0.23	W W/°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 79°C, 4.0 W CW, 7.5 Vdc, I_{DQ} = 100 mA, 520 MHz	$R_{\theta JC}$	4.4	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C, passes 1000 V
Machine Model (per EIA/JESD22-A115)	A, passes 100 V
Charge Device Model (per JESD22-C101)	IV, passes 2000 V

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	1	260	°C

Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 30 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	2	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 7.5 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	500	nAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 67 μAdc)	$V_{GS(th)}$	1.7	2.2	2.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 700 mAdc)	$V_{DS(on)}$	—	.22	—	Vdc
Forward Transconductance (V_{DS} = 7.5 Vdc, I_D = 4.0 Adc)	g_{fs}	—	4.0	—	S
Dynamic Characteristics					
Reverse Transfer Capacitance (V_{DS} = 7.5 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.63	—	pF
Output Capacitance (V_{DS} = 7.5 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	34.8	—	pF
Input Capacitance (V_{DS} = 7.5 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	57.6	—	pF

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.

(continued)

Table 5. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Functional Tests (In Freescale Narrowband Test Fixture, 50 ohm system) V_{DD} = 7.5 Vdc, I_{DQ} = 100 mA, P_{in} = 16 dBm, f = 520 MHz					
Common-Source Amplifier Output Power	P_{out}	—	4.9	—	W
Drain Efficiency	η_D	—	74.9	—	%

TYPICAL CHARACTERISTICS

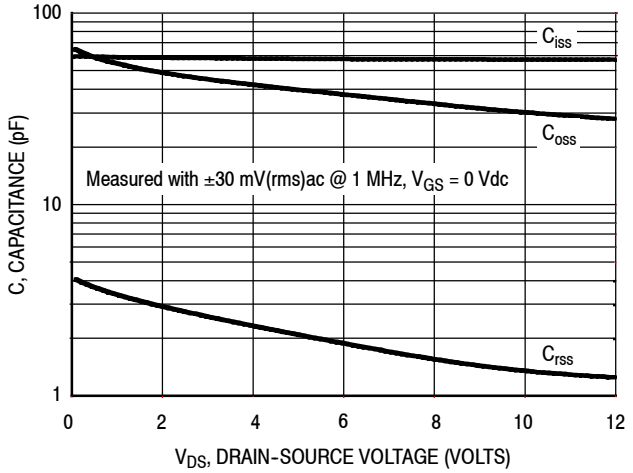
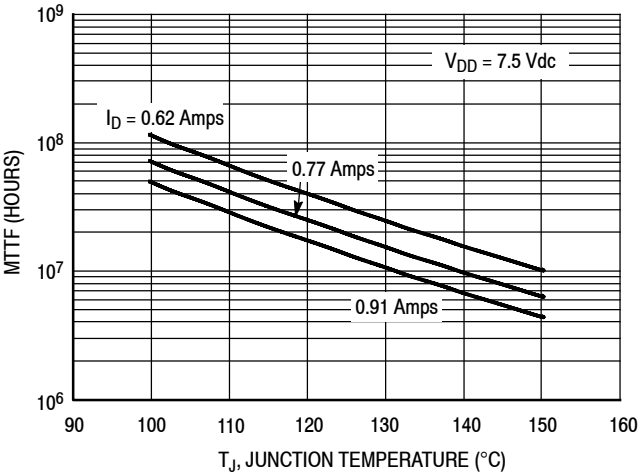


Figure 2. Capacitance versus Drain-Source Voltage



Note: MTTF value represents the total cumulative operating time under indicated test conditions.

MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

Figure 3. MTTF versus Junction Temperature — CW

520 MHz NARROWBAND PRODUCTION TEST FIXTURE

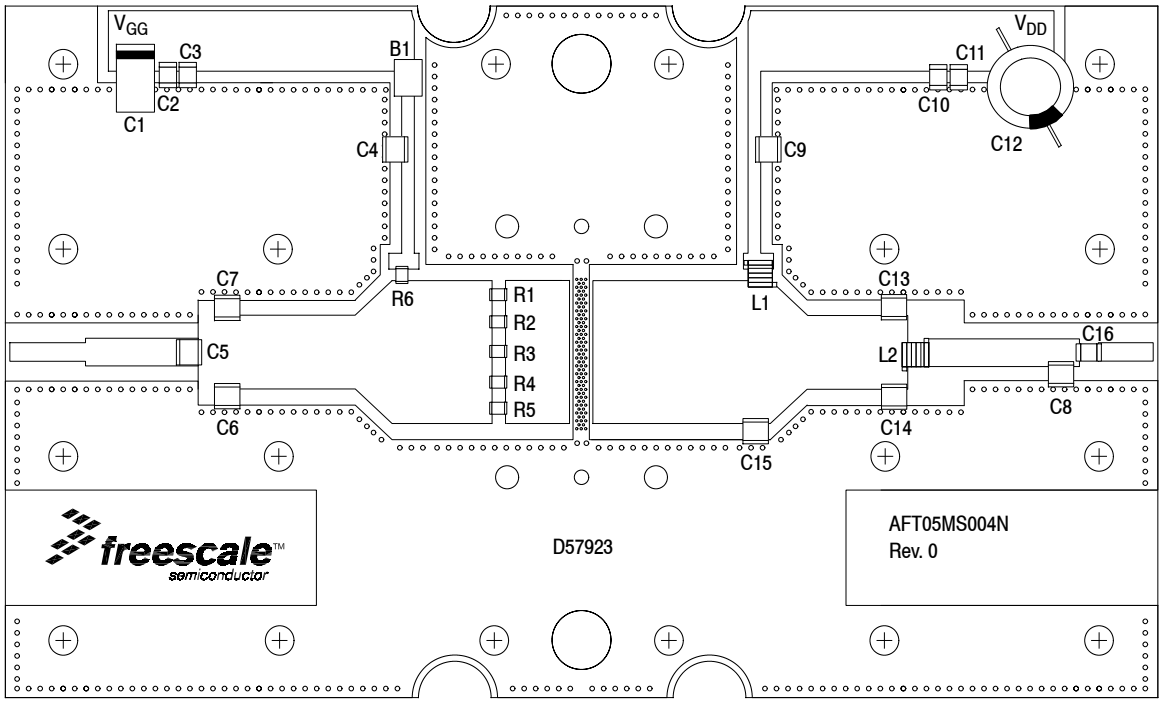


Figure 4. AFT05MS004NT1 Narrowband Test Circuit Component Layout — 520 MHz

Table 6. AFT05MS004NT1 Narrowband Test Circuit Component Designations and Values — 520 MHz

Part	Description	Part Number	Manufacturer
B1	RF Bead, Short	2743019447	Fair-Rite
C1	22 μF, 35 V Tantalum Capacitor	T491X226K035AT	Kemet
C2, C11	0.1 μF Chip Capacitors	CDR33BX104AKWS	AVX
C3, C10	0.01 μF Chip Capacitors	C0805C103K5RAC	Kemet
C4, C9	180 pF Chip Capacitors	ATC100B181JT300XT	ATC
C5	11 pF Chip Capacitor	ATC100B110JT500XT	ATC
C6, C7	13 pF Chip Capacitors	ATC100B130JT500XT	ATC
C8, C15	2.2 pF Chip Capacitors	ATC100B2R2JT500XT	ATC
C12	330 μF, 35 V Electrolytic Capacitor	MCGPR35V337M10X16-RH	Multicomp
C13, C14	16 pF Chip Capacitors	ATC100B160JT500XT	ATC
C16	9.1 pF Chip Capacitor	ATC100B9R1CT500XT	ATC
L1	8.0 nH, 3 Turn Inductor	A03TKLC	Coilcraft
L2	5 nH, 2 Turn Inductor	A02TKLC	Coilcraft
R1, R2, R3, R4, R5	1.5 Ω, 1/4 W Chip Resistors	RC1206FR-071R5L	Yageo
R6	27 Ω, 1/4 W Chip Resistor	CRCW120627R0FKEA	Vishay
PCB	Rogers RO4350, 0.030″, ε_r = 3.66	D57923	MTL

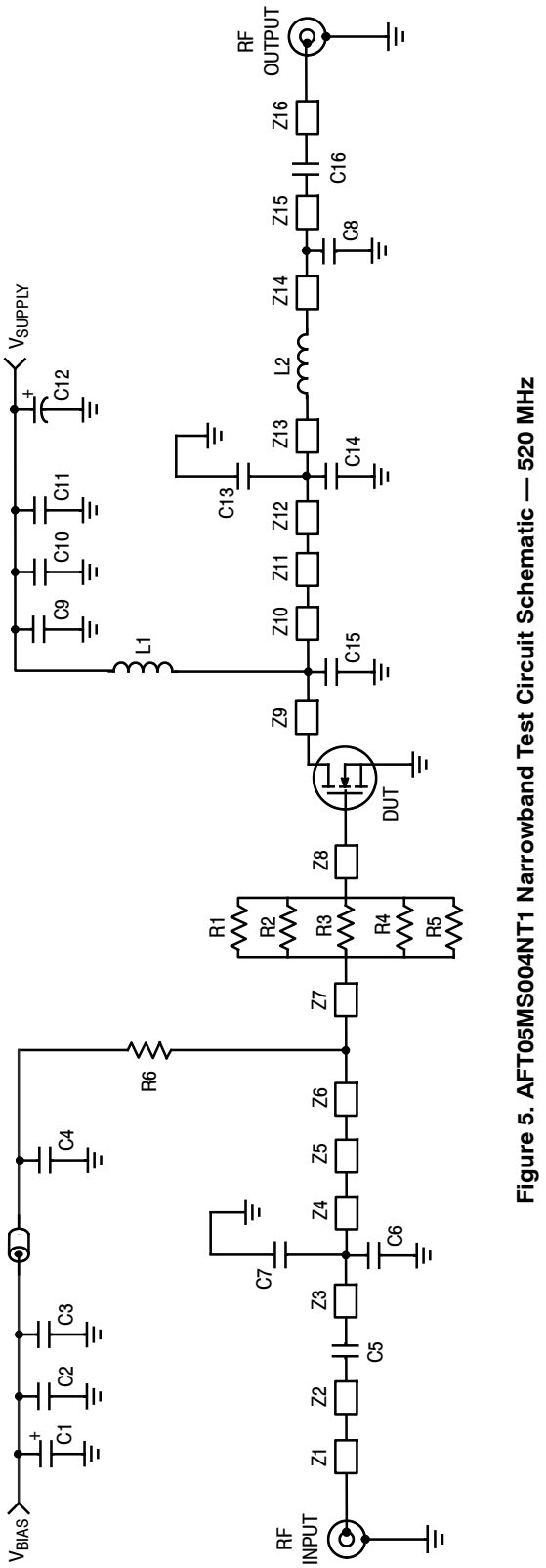


Figure 5. AFT05MS004NT1 Narrowband Test Circuit Schematic — 520 MHz

Table 7. AFT05MS004NT1 Narrowband Test Circuit Microstrips — 520 MHz

Microstrip	Description
Z1	0.328″ × 0.080″ Microstrip
Z2	0.490″ × 0.120″ Microstrip
Z3	0.055″ × 0.320″ Microstrip
Z4	0.555″ × 0.320″ Microstrip
Z5	0.160″ × 0.320″ × 0.620″ Taper Microstrip
Z6	0.045″ × 0.620″ Microstrip
Z7	0.387″ × 0.620″ Microstrip
Z8	0.273″ × 0.620″ Microstrip

Microstrip	Description
Z9	0.708″ × 0.620″ Microstrip
Z10	0.062″ × 0.620″ Microstrip
Z11	0.162″ × 0.620″ × 0.320″ Taper Microstrip
Z12	0.377″ × 0.320″ Microstrip
Z13	0.055″ × 0.320″ Microstrip
Z14	0.587″ × 0.120″ Microstrip
Z15	0.078″ × 0.120″ Microstrip
Z16	0.238″ × 0.080″ Microstrip

TYPICAL CHARACTERISTICS — 520 MHz NARROWBAND REFERENCE CIRCUIT

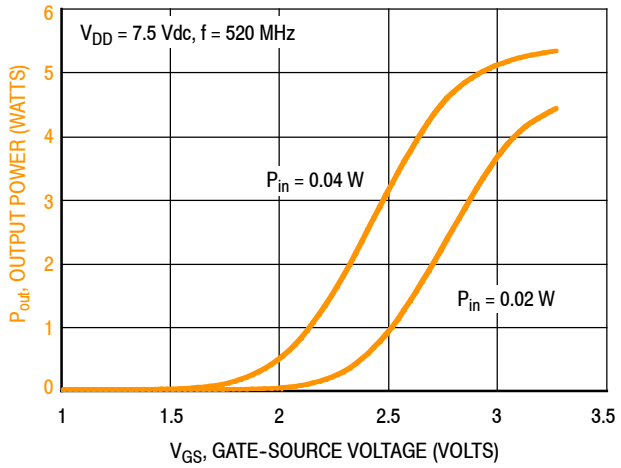


Figure 6. Output Power versus Gate-Source Voltage

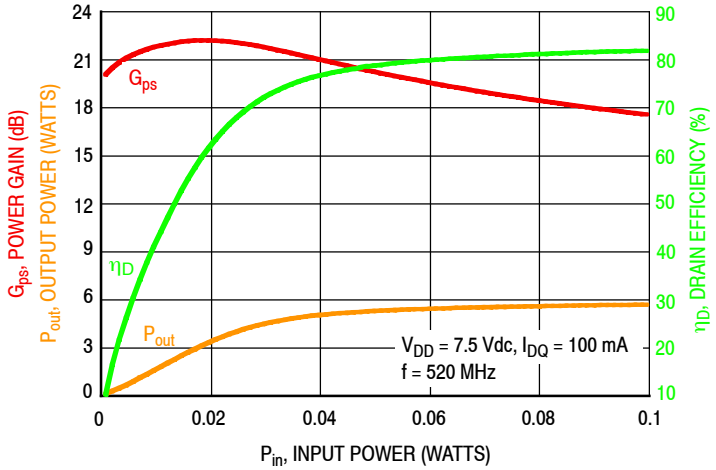


Figure 7. Power Gain, Drain Efficiency and Output Power versus Input Power

V_{DD} = 7.5 Vdc, I_{DQ} = 100 mA, P_{out} = 4 W

f MHz	Z_{source} Ω	Z_{load} Ω
520	1.35 + j2.15	2.10 + j1.70

Z_{source} = Test circuit impedance as measured from gate to ground.

Z_{load} = Test circuit impedance as measured from drain to ground.

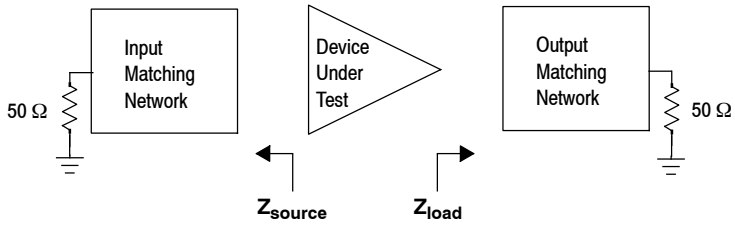


Figure 8. Narrowband Series Equivalent Source and Load Impedance — 520 MHz

Table 8. 136–174 MHz VHF Broadband Performance (In Freescale Reference Circuit, 50 ohm system)
V_{DD} = 7.5 Volts, I_{DQ} = 100 mA, T_A = 25°C, CW

Frequency (MHz)	P_{in} (W)	G_{ps} (dB)	η_D (%)	P_{out} (W)
135	0.10	17.8	62.3	6.0
155	0.06	20.2	69.1	6.0
175	0.10	17.9	61.8	6.0

Table 9. Load Mismatch/Ruggedness (In Freescale Reference Circuit)

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage, V_{DD}	Result
155	CW	> 65:1 at all Phase Angles	0.2 (3 dB Overdrive)	9.0	No Device Degradation

136–174 MHz VHF BROADBAND REFERENCE CIRCUIT

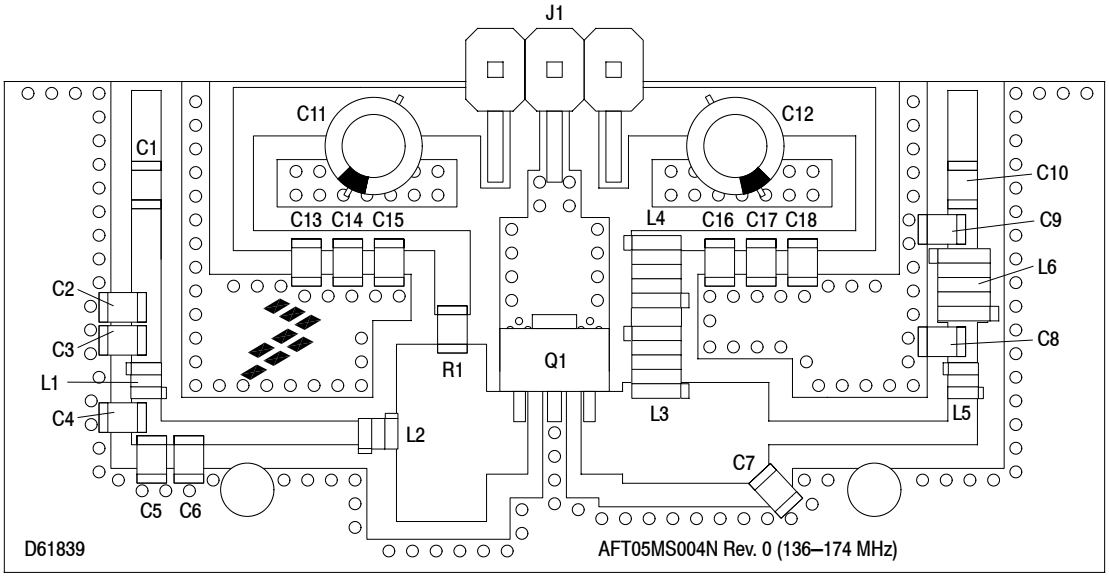


Figure 9. AFT05MS004NT1 VHF Broadband Reference Circuit Component Layout — 136–174 MHz

Table 10. AFT05MS004NT1 VHF Broadband Reference Circuit Component Designations and Values — 136–174 MHz

Part	Description	Part Number	Manufacturer
C1, C10, C14, C17	1 nF Chip Capacitors	2012X7R2E102M	TDK
C2	39 pF Chip Capacitor	ATC600F390JT250XT	ATC
C3, C8	56 pF Chip Capacitors	ATC600F560JT250XT	ATC
C4, C5	68 pF Chip Capacitors	ATC600F680JT250XT	ATC
C6, C15, C16	100 pF Chip Capacitors	ATC600F101JT250XT	ATC
C7	150 pF Chip Capacitor	ATC600F151JT250XT	ATC
C9	8.2 pF Chip Capacitor	ATC600F8R2BT250XT	ATC
C11, C12	10 μF, 50 V Electrolytic Capacitors	UVR1H100MDD	Nichicon
C13, C18	1 μF Chip Capacitors	GRM21BR71H105KA12L	Murata
J1	Breakaway Header, Right-Angle 3 Pins	22-28-8360	Molex
L1	13.7 nH Inductor	0807SQ14N	Coilcraft
L2	12.3 nH Inductor	0806SQ12N	Coilcraft
L3, L4	25.0 nH Inductors	0908SQ25N	Coilcraft
L5	15.7 nH Inductor	0806SQ16N	Coilcraft
L6	27.3 nH Inductor	0908SQ27N	Coilcraft
Q1	RF Power LDMOS Transistor	AFT05MS004NT1	Freescale
R1	33 Ω, 1/10 W Chip Resistor	CRCW080533R0JNEA	Vishay
PCB	0.020″, ε_r = 4.8, FR4 (S-1000)	D61839	MTL

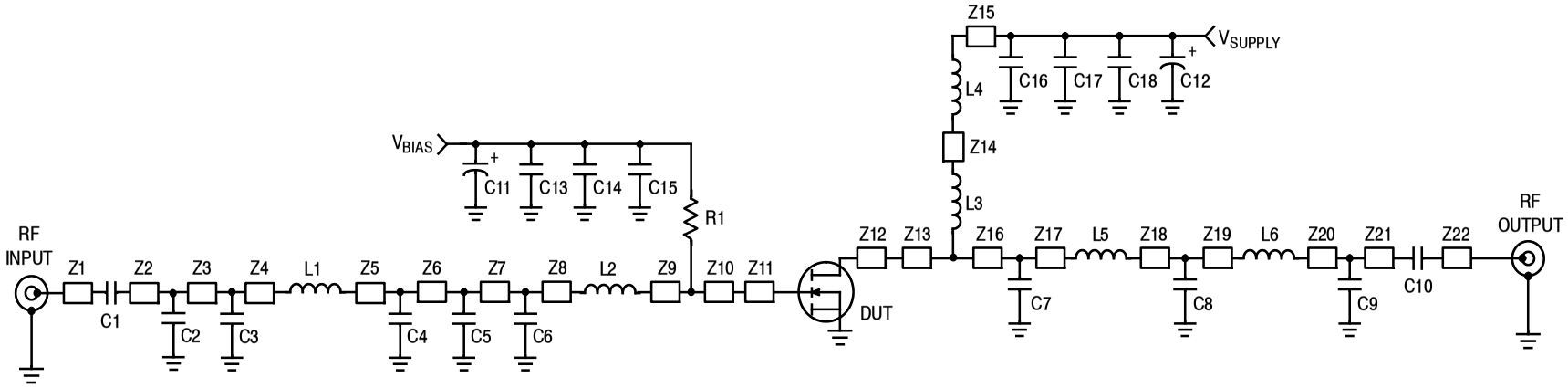


Figure 10. AFT05MS004NT1 VHF Broadband Reference Circuit Schematic — 136–174 MHz

Table 11. AFT05MS004NT1 VHF Broadband Reference Circuit Microstrips — 136–174 MHz

Microstrip	Description
Z1	0.120″ × 0.050″ Microstrip
Z2	0.142″ × 0.050″ Microstrip
Z3	0.010″ × 0.050″ Microstrip
Z4	0.012″ × 0.050″ Microstrip
Z5	0.010″ × 0.050″ Microstrip
Z6*	0.010″ × 0.050″ Microstrip
Z7	0.012″ × 0.040″ Microstrip
Z8	0.265″ × 0.040″ Microstrip

Microstrip	Description
Z9	0.070″ × 0.300″ Microstrip
Z10	0.032″ × 0.300″ Microstrip
Z11	0.070″ × 0.140″ Microstrip
Z12	0.070″ × 0.140″ Microstrip
Z13	0.015″ × 0.170″ Microstrip
Z14	0.030″ × 0.084″ Microstrip
Z15	0.040″ × 0.040″ Microstrip

Microstrip	Description
Z16	0.015″ × 0.170″ Microstrip
Z17*	0.357″ × 0.050″ Microstrip
Z18	0.010″ × 0.050″ Microstrip
Z19	0.010″ × 0.050″ Microstrip
Z20	0.010″ × 0.050″ Microstrip
Z21	0.010″ × 0.050″ Microstrip
Z22	0.120″ × 0.050″ Microstrip

* Line length includes microstrip bends

TYPICAL CHARACTERISTICS — 136–174 MHz VHF BROADBAND REFERENCE CIRCUIT

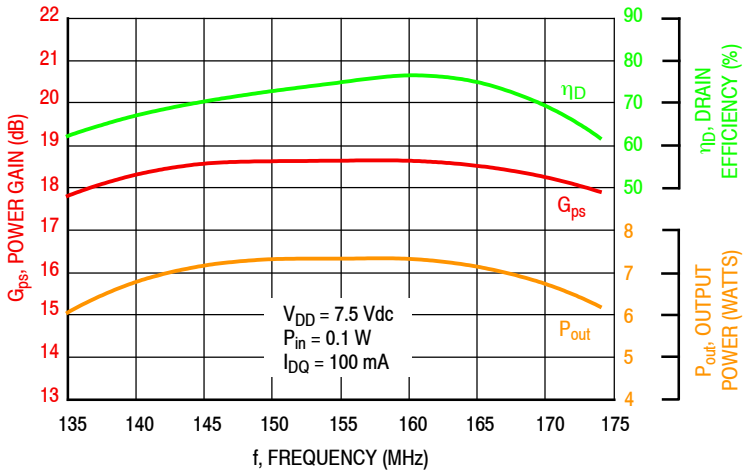


Figure 11. Power Gain, Drain Efficiency and Output Power versus Frequency at a Constant P_{in}

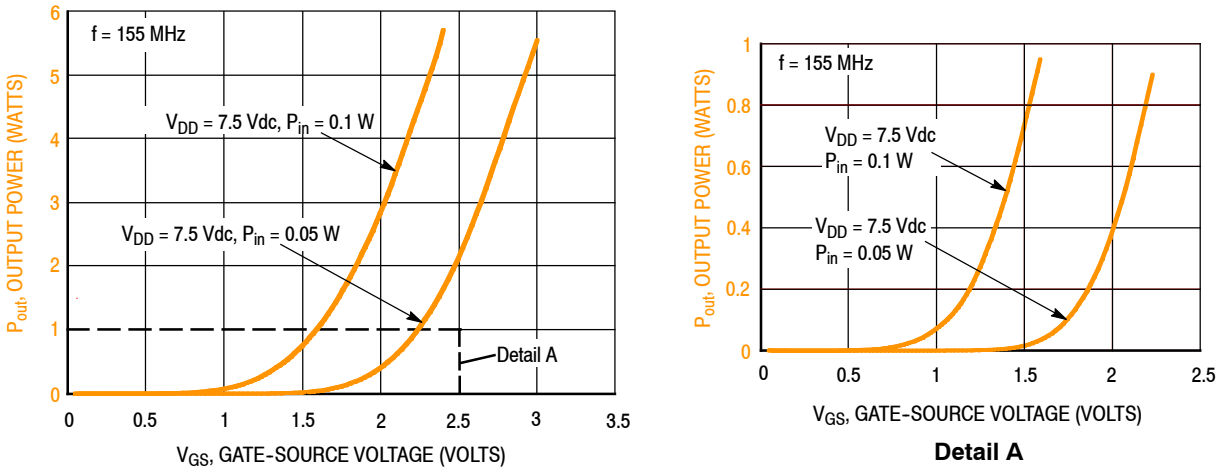


Figure 12. Output Power versus Gate-Source Voltage

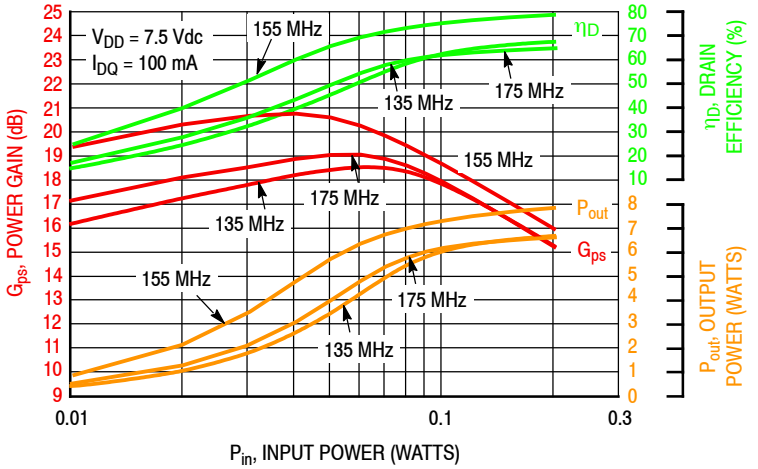
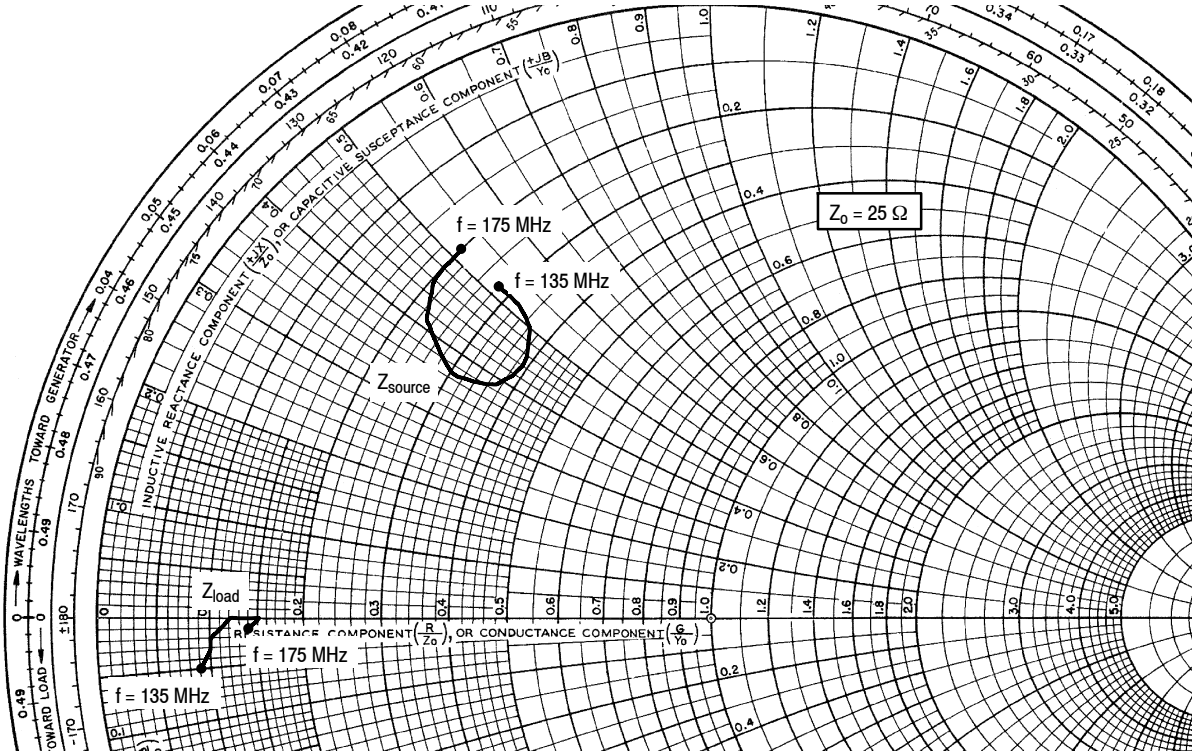


Figure 13. Power Gain, Drain Efficiency and Output Power versus Input Power and Frequency

136–174 MHz VHF BROADBAND REFERENCE CIRCUIT



V_{DD} = 7.5 Vdc, I_{DQ} = 100 mA, P_{out} = 4 W

f MHz	Z_{source} Ω	Z_{load} Ω
135	7.02 + j13.05	2.24 - j1.21
140	8.07 + j13.00	2.42 - j0.87
145	9.05 + j12.43	2.56 - j0.54
150	9.68 + j11.26	2.79 - j0.24
155	9.16 + j9.82	3.08 - j0.07
160	7.39 + j9.21	3.23 - j0.03
165	5.83 + j10.15	3.52 - j0.09
170	5.09 + j11.62	3.77 - j0.01
175	5.06 + j12.97	3.40 - j0.27

Z_{source} = Test circuit impedance as measured from gate to ground.

Z_{load} = Test circuit impedance as measured from drain to ground.

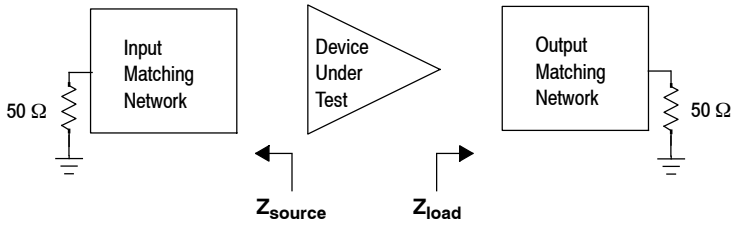


Figure 14. VHF Broadband Series Equivalent Source and Load Impedance — 136–174 MHz

Table 12. 350–520 MHz UHF Broadband Performance (In Freescale Reference Circuit, 50 ohm system)
V_{DD} = 7.5 Volts, I_{DQ} = 50 mA, T_A = 25°C, CW

Frequency (MHz)	P_{in} (W)	G_{ps} (dB)	η_D (%)	P_{out} (W)
350	0.11	15.5	48.7	4.0
470	0.04	19.8	67.7	4.0
520	0.09	16.3	71.1	4.0

Table 13. Load Mismatch/Ruggedness (In Freescale Reference Circuit)

Frequency (MHz)	Signal Type	VSWR	P_{in} (W)	Test Voltage, V_{DD}	Result
435	CW	> 65:1 at all Phase Angles	0.24 (3 dB Overdrive)	9.0	No Device Degradation

350–520 MHz UHF BROADBAND REFERENCE CIRCUIT

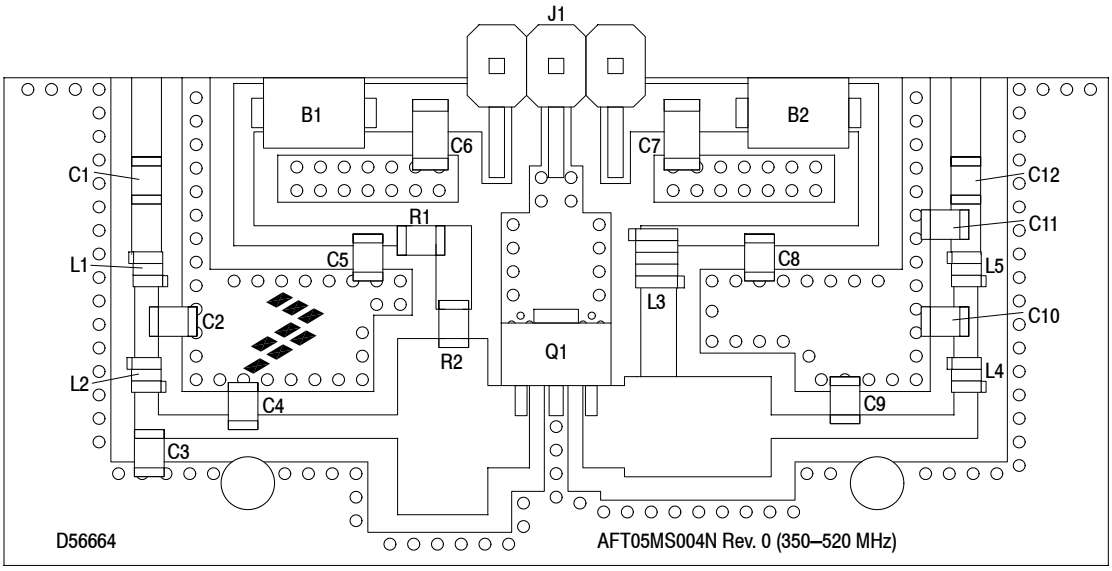


Figure 15. AFT05MS004NT1 UHF Broadband Reference Circuit Component Layout — 350–520 MHz

Table 14. AFT05MS004NT1 UHF Broadband Reference Circuit Component Designations and Values — 350–520 MHz

Part	Description	Part Number	Manufacturer
B1, B2	RF Beads	2743019447	Fair-Rite
C1, C10	18 pF Chip Capacitors	GQM2195C2E180FB12D	Murata
C5, C8, C12	100 pF Chip Capacitors	GQM2195C2E101GB12D	Murata
C2, C3	15 pF Chip Capacitors	GQM2195C2E150FB12D	Murata
C4	56 pF Chip Capacitor	GQM2195C2E560GB12D	Murata
C6	1 μF Chip Capacitor	GRM31CR72A105KA01L	Murata
C7	10 μF Chip Capacitor	GRM31CR61H106KA12L	Murata
C9	39 pF Chip Capacitor	GQM2195C2E390GB12D	Murata
C11	5.1 pF Chip Capacitor	GQM2195C2E5R1BB12D	Murata
J1	Breakaway Header, Right-Angle 3 Pins	22-28-8360	Molex
L1, L2	5.5 nH Inductors	0806SQ5N5	Coilcraft
L3	16.6 nH Inductor	0908SQ17N	Coilcraft
L4	2.55 nH Inductor	0906-3JLC	Coilcraft
L5	8.1 nH Inductor	0908SQ8N1	Coilcraft
Q1	RF Power LDMOS Transistor	AFT05MS004NT1	Freescale
R1, R2	22 Ω, 1/10 W Chip Resistors	RR1220Q-220-D	Susumu
PCB	0.020″, ε_r = 4.8, FR4 (S-1000)	D56664	MTL

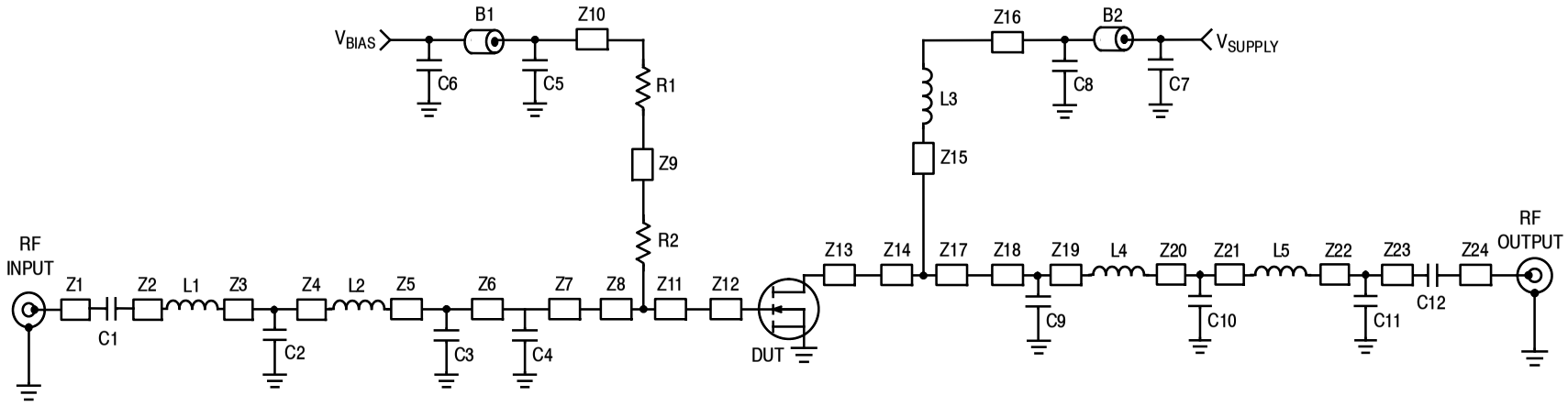


Figure 16. AFT05MS004NT1 UHF Broadband Reference Circuit Schematic — 350–520 MHz

Table 15. AFT05MS004NT1 UHF Broadband Reference Circuit Microstrips — 350–520 MHz

Microstrip	Description
Z1	0.150″ x 0.050″ Microstrip
Z2	0.090″ × 0.050″ Microstrip
Z3	0.070″ × 0.050″ Microstrip
Z4	0.070″ × 0.050″ Microstrip
Z5*	0.090″ × 0.050″ Microstrip
Z6*	0.160″ × 0.050″ Microstrip
Z7	0.260″ × 0.050″ Microstrip
Z8	0.095″ × 0.300″ Microstrip

Microstrip	Description
Z9	0.140″ × 0.060″ Microstrip
Z10	0.065″ × 0.034″ Microstrip
Z11	0.057″ × 0.300″ Microstrip
Z12	0.070″ × 0.140″ Microstrip
Z13	0.070″ × 0.140″ Microstrip
Z14	0.057″ × 0.170″ Microstrip
Z15	0.140″ × 0.060″ Microstrip
Z16	0.200″ × 0.034″ Microstrip

Microstrip	Description
Z17	0.190″ × 0.170″ Microstrip
Z18	0.150″ × 0.050″ Microstrip
Z19*	0.270″ × 0.050″ Microstrip
Z20	0.070″ × 0.050″ Microstrip
Z21	0.070″ × 0.050″ Microstrip
Z22	0.050″ × 0.050″ Microstrip
Z23	0.050″ × 0.050″ Microstrip
Z24	0.150″ × 0.050″ Microstrip

* Line length includes microstrip bends

TYPICAL CHARACTERISTICS — 350–520 MHz UHF BROADBAND REFERENCE CIRCUIT

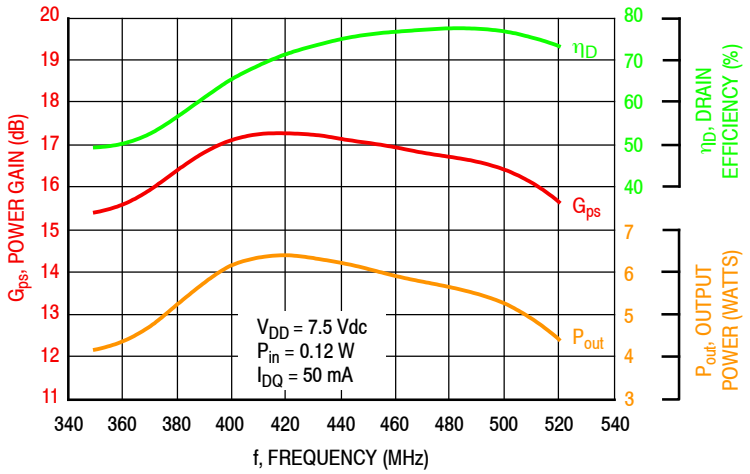


Figure 17. Power Gain, Drain Efficiency and Output Power versus Frequency at a Constant at a Constant P_{in}

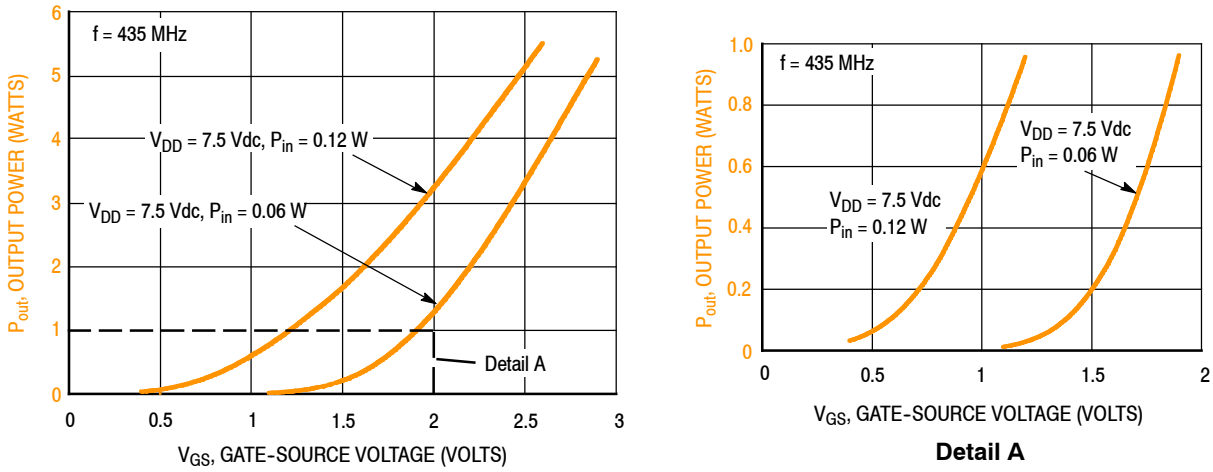


Figure 18. Output Power versus Gate-Source Voltage

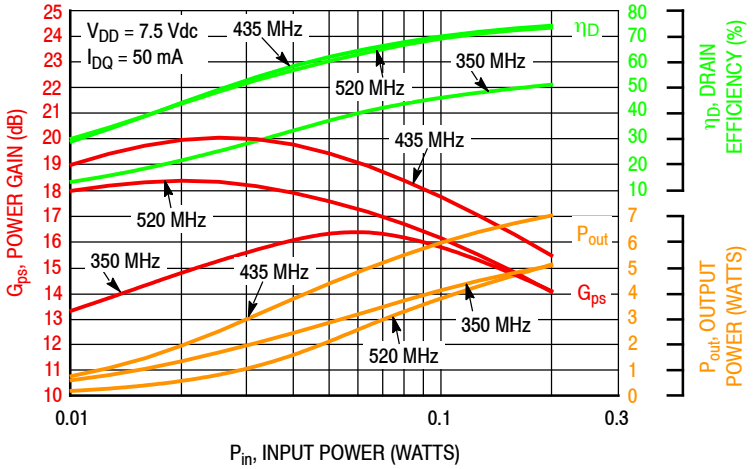
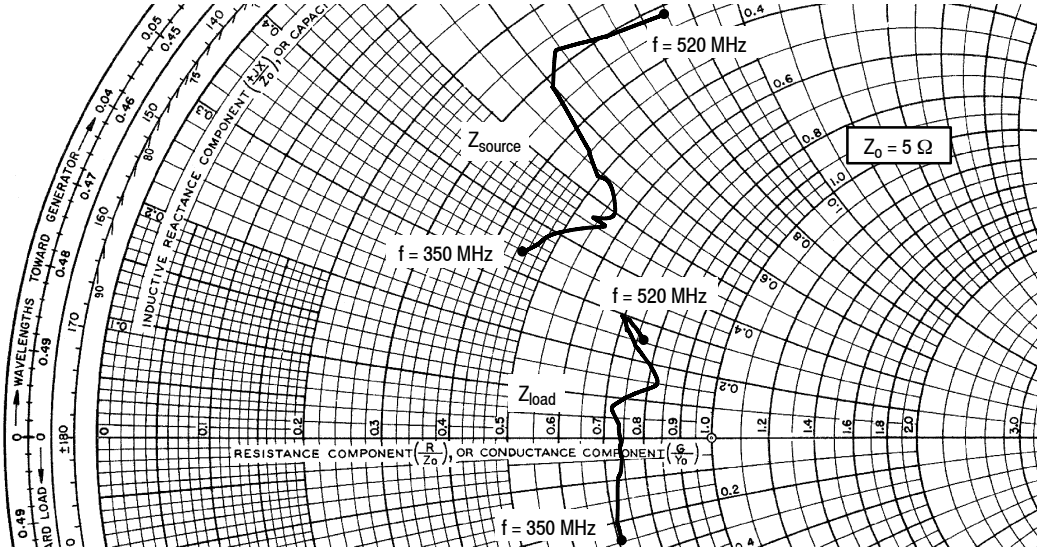


Figure 19. Power Gain, Drain Efficiency and Output Power versus Input Power and Frequency

350–520 MHz UHF BROADBAND REFERENCE CIRCUIT



V_{DD} = 7.5 Vdc, I_{DQ} = 50 mA, P_{out} = 4 W

f MHz	Z_{source} Ω	Z_{load} Ω
350	2.27 - j1.72	3.55 + j1.20
360	2.41 - j1.91	3.61 + j0.92
370	2.55 - j2.11	3.66 + j0.64
380	2.68 - j2.31	3.71 + j0.36
390	2.74 - j2.38	3.71 + j0.15
400	2.76 - j2.36	3.69 + j0.02
410	2.77 - j2.35	3.66 + j0.18
420	2.78 - j2.35	3.67 + j0.34
430	2.78 - j2.43	3.82 + j0.48
440	2.79 - j2.50	3.97 + j0.62
450	2.79 - j2.57	4.13 + j0.76
460	2.44 - j2.70	4.00 + j0.95
470	2.02 - j2.84	3.80 + j1.15
480	1.59 - j2.98	3.61 + j1.36
490	1.37 - j3.20	3.53 + j1.46
500	1.45 - j3.53	3.62 + j1.41
510	1.52 - j3.86	3.71 + j1.36
520	1.60 - j4.19	3.80 + j1.31

Z_{source} = Test circuit impedance as measured from gate to ground.

Z_{load} = Test circuit impedance as measured from drain to ground.

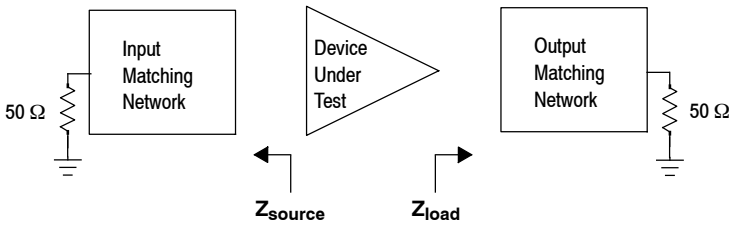


Figure 20. UHF Broadband Series Equivalent Source and Load Impedance — 350–520 MHz

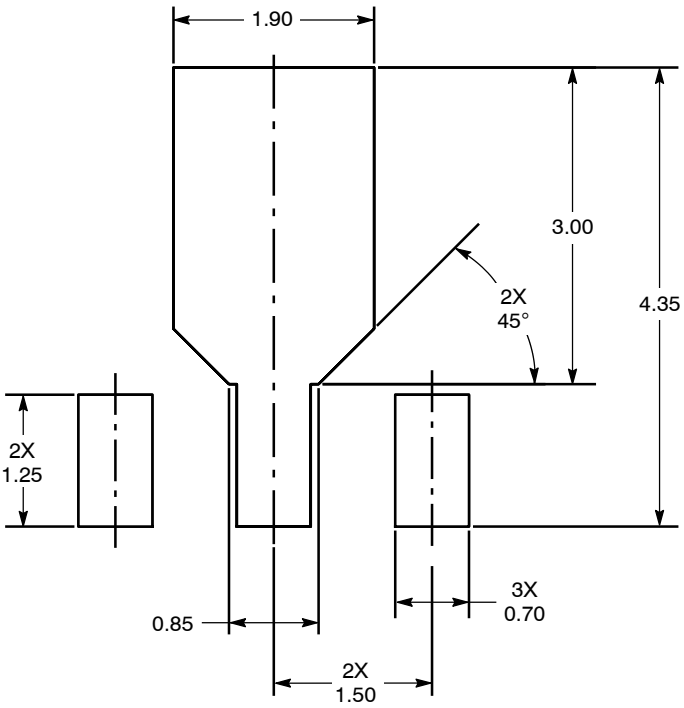


Figure 21. PCB Pad Layout for SOT-89A

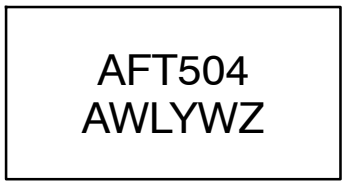
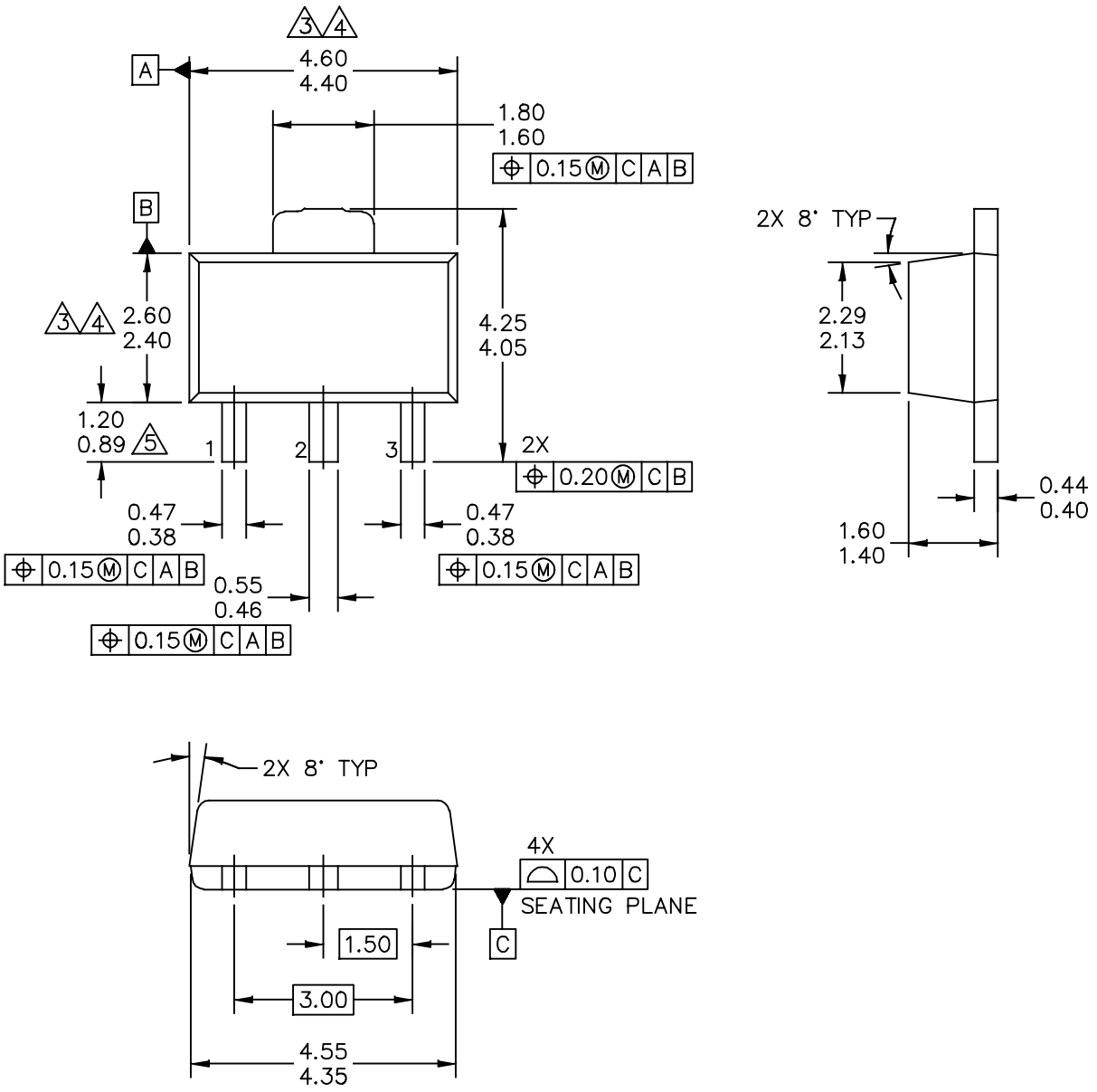
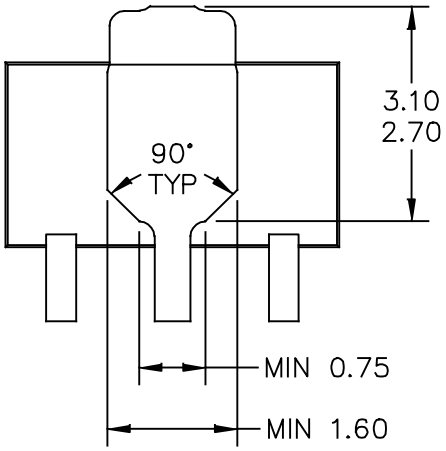


Figure 22. Product Marking

PACKAGE DIMENSIONS



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TITLE: SOT–89A, 3 LEAD, 4.5 X 2.5 PKG, 1.5 MM PITCH	DOCUMENT NO: 98ASA00241D	REV: O
	CASE NUMBER: 2142–01	15 JUL 2010
	STANDARD: NON–JEDEC	



BOTTOM VIEW

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	CASE NUMBER: 2142–01	15 JUL 2010
	STANDARD: NON–JEDEC	

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M – 1994.

2. ALL DIMENSIONS ARE IN MILLIMETERS.

3. DIMENSIONS DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.5 MM PER END. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.5 MM PER SIDE.

4. DIMENSION ARE DETERMINED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH, BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.

5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.

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	CASE NUMBER: 2142–01	15 JUL 2010
	STANDARD: NON–JEDEC	

PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following documents, software and tools to aid your design process.

Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

Software

- Electromigration MTTF Calculator
- RF High Power Model
- .s2p File

Development Tools

- Printed Circuit Boards

For Software and Tools, do a Part Number search at http://www.freescale.com, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	July 2014	• Initial Release of Data Sheet

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